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(56) References cited:
EP-A- 0 194 861
US-A- 4 575 580

SYSTEMS-COMPUTERS-CONTROL, vol. 13, no. 3, May-June 1982; pages 30-39, Silver Spring, Maryland, US; Y. SATO et al.: "A pressure-sensitive device for input of graphics"

PATENT ABSTRACTS OF JAPAN, vol. 8, no. 38 (P-255)[1475], 18th February 1984;& JP-A-58 191 089

PATENT ABSTRACTS OF JAPAN, vol. 8, no. 202 (P-300)[1639], 14th September 1984;& JP-A-59 88 583

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(3.10/3.6/3.3. 1)

Description

This invention relates to a graphics input tablet. The invention is particularly useful in the data processing field where it may be employed to input data of a graphical nature into a data processing machine.

Background Art

In the data processing field one of the major problems to users of a system is the rapid inputting of data. This has traditionally been achieved with a keyboard but when it is necessary to input graphical data, rather than character strings, a keyboard is grossly inefficient. There are various examples in the prior art of attempts to provide a more efficient and easier to use input means for graphical data.

One such example is disclosed in EP-A-5,996 (Quest Automation Ltd.) which shows an electrographic apparatus with two resistive layers, one overlying the other, held apart by a framework but arranged to be brought into contact by the pressure of a stylus or similar. Excitation voltages are applied to the resistive layer at 90 degrees to each other and two analogue voltages related to the position of the stylus are obtained in an unspecified manner.

Another example is disclosed in GB 2,088,063 (Robert Branton). This shows a conductive layer overlying a rectangular resistive layer with an insulating mesh between the two. The resistive layer has a contact at each corner and one opposed pair of contacts is energised at any one time. A stylus (ball-point pen or similar) is pressed onto the upper, conductive layer which then makes contact, through a gap in the insulating mesh, with the resistive layer. In consequence, the potential of the conductive layer equals that of the resistive layer at the point of contact; since this varies with the relative distances of the point from each of the polarised contacts, the potential of the conductive layer provides information to identify the position of the stylus. Once the position with respect to these polarised contacts is established they are de-energised and the other pair is polarised to give information regarding the position of the stylus along a different axis. Thus the position of the stylus in 2 dimensions may be identified.

EP-A-194,861 (Elographics Inc) discloses an electrographic touch sensor having z-axis capability. The x, y and z coordinates are calculated from voltage signals in a resistive layer of material. The voltage signals for each coordinate are generated during a separate time interval.

JP Abstract 58 191 089 describes a position detecting method in which an electrically insulated writing tool is used to sandwich a pressure conductive rubber sheet between a conductive film and a planar resistor. A voltage is applied to the conductive film.

The article titled 'A Pressure-sensitive Device for Input of Graphics' 8169 Systems-Computers-Control, Vol. 13 (1982) May - June, No 3, Silver Spring, Maryland, USA describes a pressure-sensitive device for input of graphics in which a resistive sheet is used to detect the x-coordinate and a separate resistive sheet is used to detect the y-coordinate.

Summary of the Invention

The ability to input 3 dimensional data using the tablet alone is very useful, for example a) to define the colour and/or intensity of a location on graphic terminal or b) for signature verification where the profile of the pressure applied across the signature would be a useful additional check, above and beyond a 2 dimensional check of the appearance of the signature. Pressure information could be useful, for example in the case of a one dimensional position-detecting tablet in the form of a strip. This would provide 2 dimensional input capability without occupying the large area taken up by a prior art 2-d input tablet.

Accordingly, the present invention provides a graphics input tablet comprising a layer of electrically resistive material supported coextensively with a layer of electrically conductive material to provide a flat tablet surface, first and second conductors connected respectively to first and second portions of the resistive layer, said portions being spaced apart on a notional x-axis across the tablet surface, third and fourth conductors connected respectively to third and fourth portions of the resistive layer, said portions being spaced apart on a notional y-axis, intersecting the notional x-axis; the arrangement being such that when an electrical potential is applied between the resistive layer and the conductive layer and localised pressure is applied to the tablet surface, currents flow from the conductors through the resistive layer to the conductive layer, the relative magnitudes of these currents being related to the respective distances of the region of applied pressure from the first and second portions and the third and fourth portions respectively, the resistive material has the property that the electrical resistance between the layers in the region of the localised pressure applied thereto changes monotonically with the applied pressure and when the localised pressure is applied, the total current flowing between the resistive sheet and the conductive sheet is related to the magnitude of the applied pressure and provides a measurement from which a z-axis value may be calculated; characterised in that electrical sensing means are arranged to measure individually at the same time, the current flowing in each of the conductors and to calculate subsequently a value representing an x, y and z-coordinate of the region of localised pressure.

This provides the facility to detect the position of a stylus in 3 dimensions, ie two linear dimensions and one pressure dimension.

The resistive layer may be in the form of a single sheet of material. Alternatively, the resistive layer may comprise two sheets, each of a resistive material, the conductors being connected to a first of said sheets and the second of said sheets having the property as aforesaid that the electrical resistance between the layers in the region of localised pressure applied thereto changes monotonically with the magnitude of the pressure applied to the layers.

Description of the Drawings

Fig. 1a shows schematically a cross-section through a graphics input tablet according to the present invention.

Fig. 1b shows schematically a cross-section through an alternative embodiment of a graphics input tablet according to the present invention.

Fig. 2 shows schematically a plan view of the tablet of Fig. 1a.

Fig. 3a shows schematically a circuit for processing signals representing positional and pressure information produced by the present invention.

Fig. 3b shows schematically a circuit for inputting the outputs of the circuit of Fig. 3a into a computer.

Fig. 4 shows schematically an alternative circuit for processing signals representing positional and pressure information produced by the present invention and inputting this into a computer.

Fig. 5 is a schematic graph showing variations in positional measurements versus actual position when employing the present invention.

Fig. 6 is a schematic graph showing variations in measured total current versus actual force applied to a small area using the present invention.

Detailed Description of the Invention

Fig. 1a shows a graphics input tablet according to the present invention. Layer 10 is a compressible resistive sheet known as Vermahide (Trade Mark). This material has the property that its localised electrical resistance reduces with increased pressure exerted on it as the electrically conducting fibres which make it up are forced into more intimate contact. Beneath layer 10 is layer 11 which is an electrically conducting coat applied to insulating substrate 13. Beneath insulating substrate 13 is conductive coat 50 which may be electrically grounded to give electrostatic screening. Layers 11, 13, 50 may conveniently be provided by double-sided unetched printed circuit board. Overlying layers 10, 11, 13, 50 is protective sheet 12 which is electrically insulating, physically hard-wearing and yet locally elastically deformable. Electrical connection is made to conductive layer 11 by conductor 30 and to opposed edges of resistive layer 10 by conductors 14, 15, 21, 22 (see Fig. 2).

Fig. 1b shows an alternative tablet comprising two resistive sheets, one compressible 10a and one rigid 10b. Conductive layer 11 overlies the resistive sheets and is locally elastically deformable.

Fig. 2 shows a plan view of the tablet in Fig. 1a. Contact pads 16, 17, 23, 24 are shown, attached to conductors 14, 15, 21, 22 respectively. Each contact pad makes electrical contact with a portion of the resistive layer: 16, 17, 23, 24 contacting 18, 19, 25, 26 respectively. This leaves the remainder 20 of layer 10 as the input region where a user applies localised pressure with a stylus, causing currents to flow in conductors 14, 15, 21, 22.

Fig. 3a shows one technique for producing signals x, y, z representing the position of pressure applied on region 20 (x, y) and the magnitude of pressure applied (z). Four current sense amplifiers (44) are provided for measuring the current flowing in the conductors 14, 15, 21, 22. The outputs of the currents sense amplifiers are fed into two analogue summing circuits 35, 37 one 35 for conductors 14, 15 covering the x dimension and the other 37 for conductors 21, 22 covering the y dimension. The outputs of these summers are fed into dividers 36 and 38 respectively, along with one of the current sense outputs in each case. The signal for x (and similarly for y) which this produces is not the simple ratio of currents in opposed conductors 14, 15 (or 21, 22); rather, if current in 14 = $I1$ and current in 15 = $I2$ then the value of x is:

$$x = \frac{I2}{I1+I2}$$

This function is selected since it provides a result which varies approximately rectilinearly between 0 and 1.

The signal for z, representing the pressure applied by the stylus is simply a sum of the individual currents in conductors 14, 15, 21, 22. This is obtained by summing in 39 the sums of x and y currents produced by 35 and 37 respectively.

Fig. 3b shows a circuit for inputting x, y and z to a computer. The multiplexer 40 selects each of x, y, z in turn to forward to the analogue to digital convertor 41. The results are fed to buffer 42 and thence to data bus 43 which is connected to the computer.

Fig. 4 shows an alternative arrangement to that of Figs. 3a, 3b. In this case there is an additional current sense amplifier 45 for directly measuring the current in conductor 30. This avoids the expense and inaccuracy of analogue summing circuit 39 (used in conjunction with 35 and 37). Further, the generation of the x and y functions is performed in the computer so the tablet does not need the local intelligence provided by circuits 35, 36, 37, 38. This approach has the disadvantage that more processing is necessary in the computer so the maximum sampling rate will be lower but it does not require circuits 35, 36, 37, 38, 39 so the hardware may well be cheaper to produce.

In use, the conductive layer 11 of the tablet is held at a voltage equal to -10 Volts. The conductors 14, 15, 21, 22 along the edges of resistive layer 10 are held at 0 Volts. When no pressure is applied to the upper surface of the tablet the physical contact between layers 10 and 11 is very slight and no significant current flows between them. However, when localised pressure is applied to the upper surface the layers 10 and 11 are pushed into physical and electrical contact so that a current flows from conductive layer 11 to the conductors 14, 15, 21, 22 connected to resistive layer 10. The current through each of these conductors is in inverse relation to the distance from the respective contact pad to the point where pressure is applied.

Another possibility is to have the arrangement as shown in Fig. 4 but without sense amplifier 45 (and its associated resistor). In this case the computer must sum all four conductor currents digitally. This is a processing overhead which reduces the maximum sampling rate but the hardware will be still cheaper to produce.

Fig. 5 shows the variation in the measured value of x versus the actual position at which pressure is applied. It can be seen that there are significant edge effects which mean that it may be necessary to process digitally the measurements once they are received by the computer in order to expand the measured x values to cover the entire range from 0 to 1 (0 is the left-hand edge of area 20 and 1 is the right-hand edge). It may also be necessary to take account of the y displacement when expanding the x readings since the x readings are compressed when taken near $y=0$ or $y=1$ compared to readings taken near $y=0.5$. This is shown by the two lines on Fig. 5, line A being taken at $y=0.5$ (ie across the centre of the tablet) and line B being taken at $y=0.9$ (ie near the upper edge of the tablet).

Fig. 6 shows the variation in measured total current (ie z) versus force applied to an area of tablet 1.5 millimetres square. It can be seen that this too would benefit from some digital processing, since the line produced is not as straight as ideally it should be. This would be straight forward to achieve if necessary, for example by employing a look-up table correlating measured current to applied pressure. It will be noted that below a certain non-zero value for the pressure the measured total current is zero. This is useful since it means that light pressure (eg from a person's hand) will not be detected by the tablet and will not interfere with the normal operation of the tablet.

The variation in current with applied pressure stems from 2 effects. The first of these is that the resistive material compresses locally, so reducing the electrical resistance in the region of applied pressure since the fibres in the material are in better electrical contact. The second and more significant effect is that the contact area between the conductive and resistive layers increases.

The increase in contact area with increased pressure can cause the measured position to be in error. This happens when the pressure is applied significantly closer to one contact pad than to the opposed contact pad (eg closer to 16 than to 17). The increase in contact area with pressure is uniform in all directions but since the contact area is closer to 16 than to 17, the distance from the contact area edge to 16 reduces by a greater percentage than the distance from the contact area edge to 17. This causes the measured position to appear further towards the near edge as more pressure is applied. If this effect is unacceptable then it would be necessary to compensate for it digitally in the computer by weighting the position measurement towards the centre, the level of weighting increasing with increasing pressure (ie increasing total current).

Another compensation which may be required is to allow for the fact that, at a constant pressure, the total current increases as the contact point approaches any edge of the tablet. This is because the overall resistance through the resistive sheet from the contact point to the contact pads 16, 17, 23, 24 decreases as the contact point moves further from the centre and closer to 1 or 2 of the contact pads. If this effect is too large to be ignored then a suitable weighting could be applied when the data is processed.

The rate at which the location and pressure of the stylus are sampled will depend on the requirements of the application and the circuitry and computer software employed. For graphics input to a terminal and for signature verification a sampling rate of around 10 kHz may be acceptable although a rate of around 20 kHz is preferable.

Claims

1. A graphics tablet comprising:
   a layer of electrically resistive material (10) supported coextensively with a layer of electrically conductive material (11) to provide a flat tablet surface;
   first and second conductors (14, 15) connected respectively to first and second portions of the resistive layer (18, 19), said portions being spaced apart on a notional x-axis across the tablet surface;
   third and fourth conductors (21, 22) connected respectively to third and fourth portions of the resistive layer (25, 26), said portions being spaced apart on a notional y-axis, intersecting the notional x-axis;
   the arrangement being such that when an electrical potential is applied between the resistive layer and the conductive layer and localised pressure is applied to the tablet surface, currents flow from the conductors through the resistive layer to the conductive layer, the relative magnitudes of these currents being related to the respective distances of the region of applied pressure from the first and second portions and the third and fourth portions respectively, the resistive material has the property that the electrical resistance between the layers in the region of the localised pressure applied thereto changes monotonically with the applied pressure and when the localised pressure is applied, the total current flowing between the resistive sheet and the conductive sheet is related to the magnitude of the applied pressure and provides a measurement from which a z-axis value may be calculated;
   characterised in that electrical sensing means (35-44) are arranged to measure individually at the same time, the current flowing in each of the conductors and to calculate subsequently a value representing an x,y and z-coordinate of the region of localised pressure.

2. A graphics tablet as claimed in Claim 1 wherein the x-coordinate of the position of the localised pressure is calculated by dividing the current flowing in the first conductor (14) by the sum of the currents flowing in the first and second conductors (14, 15).

3. A graphics tablet as claimed in any of Claims 1 or 2 wherein the y-coordinate of the position of the localised pressure is calculated by dividing the current flowing in the third conductor (21) by the sum of the currents flowing in the third and fourth conductors (21, 22).

4. A graphics tablet as claimed in any of the preceding Claims wherein the z-coordinate is calculated from the sum of the individual currents measured in each of the conductors (14, 15, 21, 22).

5. A graphics tablet as claimed in any of Claims 1 to 3 further comprising:
   a fifth conductor (30) connected to the conductive material (11); and
   electrical sensing means (45) arranged to measure directly, at the first sample time, the total current flowing between the resistive layer and the conductive material, thereby providing a measurement from which the z-coordinate may be calculated.

Patentansprüche

1. Graphisches Eingabetablett, umfassend:
   eine Schicht eines mit einem elektrischen Widerstand behafteten Materials (10), das flächengleich mit einer Schicht eines elektrisch leitenden Materials (11) gestützt wird, um eine ebene Tablettoberfläche zu bilden;
   erste und zweite Leiter (14, 15), die an erste beziehungsweise zweite Bereiche der mit einem Widerstand behafteten Schicht (18, 19) angeschlossen sind, wobei die Bereiche durch eine über die Tablettoberfläche verlaufende fiktive x-Achse voneinander getrennt sind;
   dritte und vierte Leiter (21, 22), die an dritte beziehungsweise vierte Bereiche der mit einem Widerstand behafteten Schicht (25, 26) angeschlossen sind, wobei die Bereiche durch eine über die Tablettoberfläche verlaufende fiktive y-Achse voneinander getrennt sind, die die fiktive x-Achse schneidet;
   wobei die Anordnung derart gestaltet ist, daß beim Anlegen einer elektrischen Spannung zwischen der mit einem Widerstand behafteten Schicht und der leitenden Schicht und beim Ausüben eines örtlichen Drucks auf die Tablettoberfläche Ströme von den Leitern durch die mit einem Widerstand behaftete Schicht zur leitenden Schicht fließen, wobei die relative Größenordnung dieser Ströme mit dem jeweiligen Abstand der Region des ausgeübten Drucks zu den ersten und zweiten Bereichen beziehungsweise zu den dritten und vierten Bereichen in Beziehung steht, wobei das mit einem Widerstand behaftete Material über die Eigenschaft verfügt, daß der elektrische Widerstand zwischen den Schichten in der Region

des hierauf örtlich ausgeübten Drucks sich gleichförmig mit dem ausgeübten Druck verändert und daß bei ausgeübtem örtlichem Druck der Gesamtstrom, der zwischen der mit einem Widerstand behafteten Lage und der leitenden Lage fließt, mit der Größenordnung des ausgeübten Drucks in Beziehung steht und eine Messung ermöglicht, amhand derer ein z-Achsen-Wert berechnet werden kann;

dadurch gekennzeichnet, daß elektrische Erfassungseinrichtungen (35-44) angebracht sind, um einzeln und zum gleichen Zeitpunkt den in jedem der Leiter fließenden Strom zu messen und nachfolgend einen Wert zu berechnen, der eine x-, y- und z-Koordinate der Region des örtlichen Drucks widerspiegelt.

2. Graphisches Tablett nach Anspruch 1, wobei die x-Koordinate der Position des örtlichen Drucks berechnet wird, indem der im ersten Leiter (14) fließende Strom durch die Summe der im ersten und zweiten Leiter (14, 15) fließenden Ströme dividiert wird.

3. Graphisches Tablett nach irgendeinem der Ansprüche 1 oder 2, wobei die y-Koordinate der Position des örtlichen Drucks berechnet wird, indem der im dritten Leiter (21) fließende Strom durch die Summe der im dritten und vierten Leiter (21, 22) fließenden Ströme dividiert wird.

4. Graphisches Tablett nach irgendeinem der vorausgehenden Ansprüche, wobei die z-Koordinate aus der Summe der einzelnen, in jedem der Leiter (14, 15, 21, 22) gemessenen Ströme berechnet wird.

5. Graphisches Tablett nach irgendeinem der Ansprüche 1 bis 3, desweiteren umfassend:
einen fünften Leiter (30), der an das leitende Material (11) angeschlossen ist; und
elektrische Erfassungseinrichtungen (45), die so angelegt sind, daß sie direkt, bei der ersten Abfragezeit, den gesamten Strom messen, der zwischen der mit einem Widerstand behafteten Schicht und dem leitenden Material fließt, wobei sie dabei eine Messung liefern, anhand derer die z-Koordinate berechnet werden kann.

Revendications

1. Tablette de données graphiques comprenant:
une couche de matériau électriquement résistant (10) portée dans la même direction qu'une couche de matériau électriquement conducteur (11) pour fournir une surface de tablette plate;
des premier et deuxième conducteurs (14, 15) connectés respectivement aux troisième et quatrième portions de la couche résistante (18, 19), lesdites portions étant séparées sur un axe théorique x traversant la surface de la tablette;
des troisième et quatrième conducteurs (21, 22) connectés respectivement aux troisième et quatrième portions de la couche résistante (25, 26), lesdites portions étant séparées sur un axe théorique y faisant intersection avec l'axe théorique x;
L'agencement étant tel que, lorsqu'un potentiel électrique est appliqué entre la couche résistante et la couche conductrice et qu'une pression localisée est appliquée sur la surface de la tablette, des courants circulent depuis les conducteurs en passant dans la couche résistante jusqu'à la couche conductrice, les valeurs relatives de ces courants étant en rapport avec les distances respectives de la région sur laquelle est appliquée la pression depuis respectivement les première et deuxième portions et les troisième et quatrième portions, le matériau résistant a comme propriété que la résistance électrique entre les couches dans la région sur laquelle est appliquée la pression, change monotoniquement avec la pression appliquée, et lorsque la pression localisée est appliquée, le courant total circulant entre la feuille résistante et la feuille conductrice est en rapport avec la valeur de la pression appliquée et fournit une mesure à partir de laquelle une valeur d'axe z peut être calculée;
caractérisée en ce que des moyens de détection électriques (35, 44) sont agencés pour mesurer séparément au même moment le courant circulant dans chacun des conducteurs, et pour calculer ensuite une valeur représentant une coordonnée x, y, et z de la région ayant la pression localisée.

2. Tablette de données graphiques selon la revendication 1, dans laquelle la coordonnée x de la position de la pression localisée est calculée en divisant le courant circulant dans le premier conducteur (14) par la somme des courants circulant dans les premier et deuxième conducteurs (14, 15).

3. Tablette de données graphiques selon l'une quelconque des revendications 1 ou 2, dans laquelle la coordonnée y de la position de la pression localisée est calculée en divisant le courant circulant dans le troisième conducteur (21) par la somme des courants circulant dans les troisième et quatrième conducteurs (21, 22).

4. Tablette de données graphiques selon l'une quelconque des revendications précédentes, dans laquelle la coordonnée z est calculée à partir de la somme des courants distincts mesurés dans chacun des conducteurs (14, 15, 21, 22).

5. Tablette de données graphiques selon l'une quelconque des revendications 1 à 3, comprenant en outre:

   un cinquième conducteur (30) connecté au matériau conducteur (11); et

   des moyens de détection électriques (45) agencés pour mesurer directement, au premier temps d'échantillonnage, le courant total circulant entre la couche résistante et le matériau conducteur, fournissant de ce fait une mesure à partir de laquelle la coordonnée z peut être calculée.

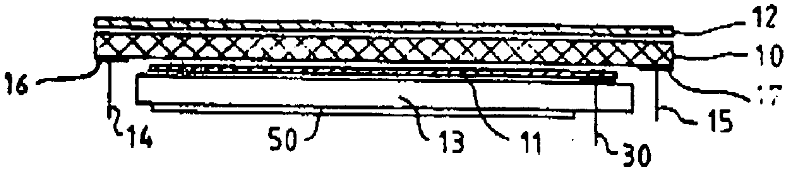

FIG. 1a

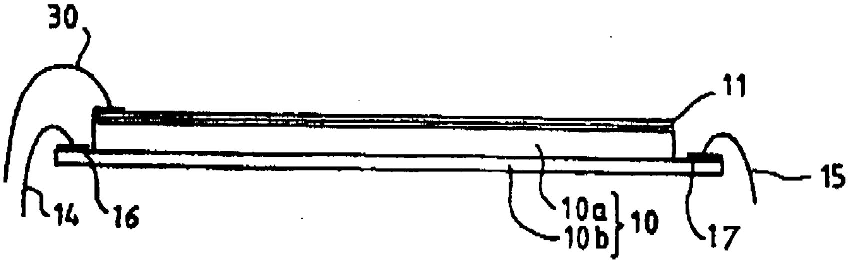

FIG. 1b

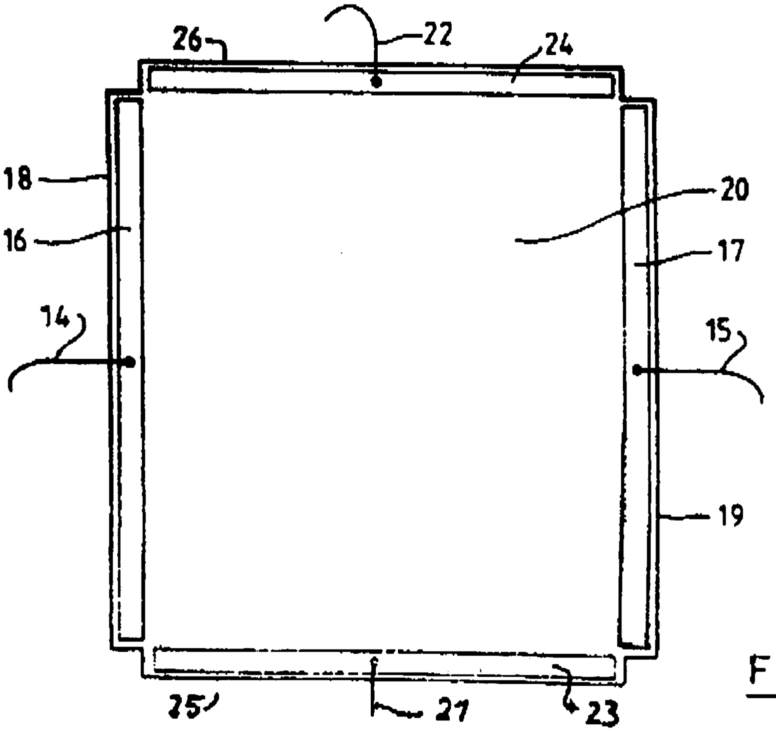

FIG 2

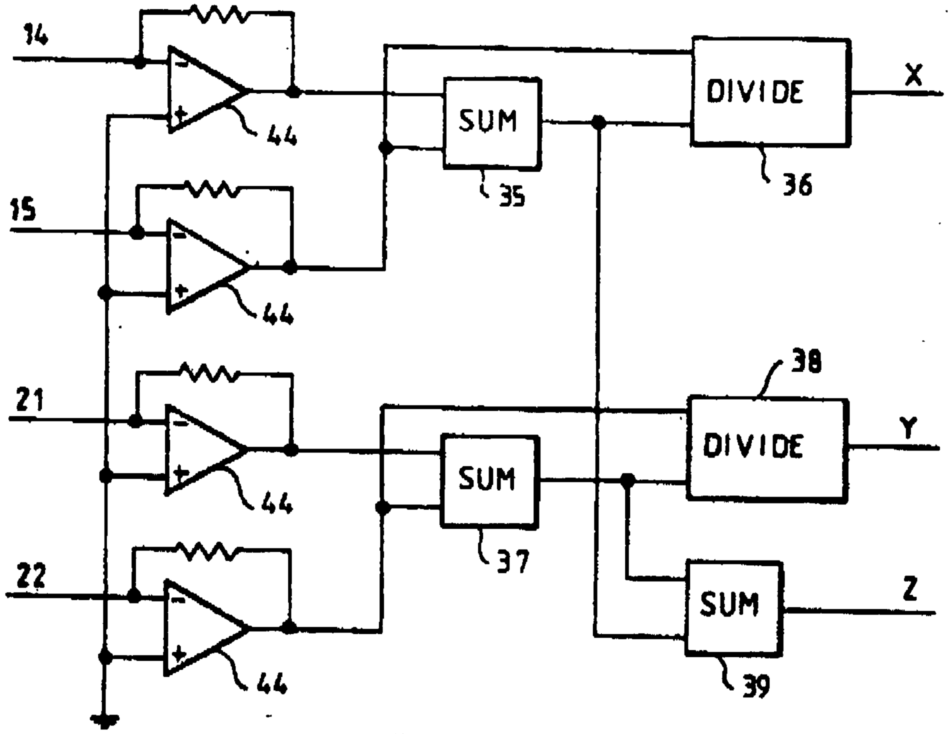
SUM
SUM
DIVIDE
X
DIVIDE
Y
SUM
Z

FIG. 3a

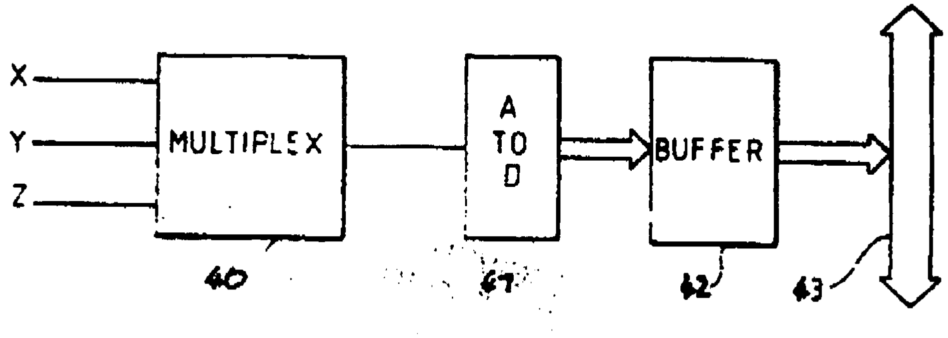
X
Y
Z
MULTIPLEX
40
A
TO
D
41
BUFFER
42
43

FIG. 3b

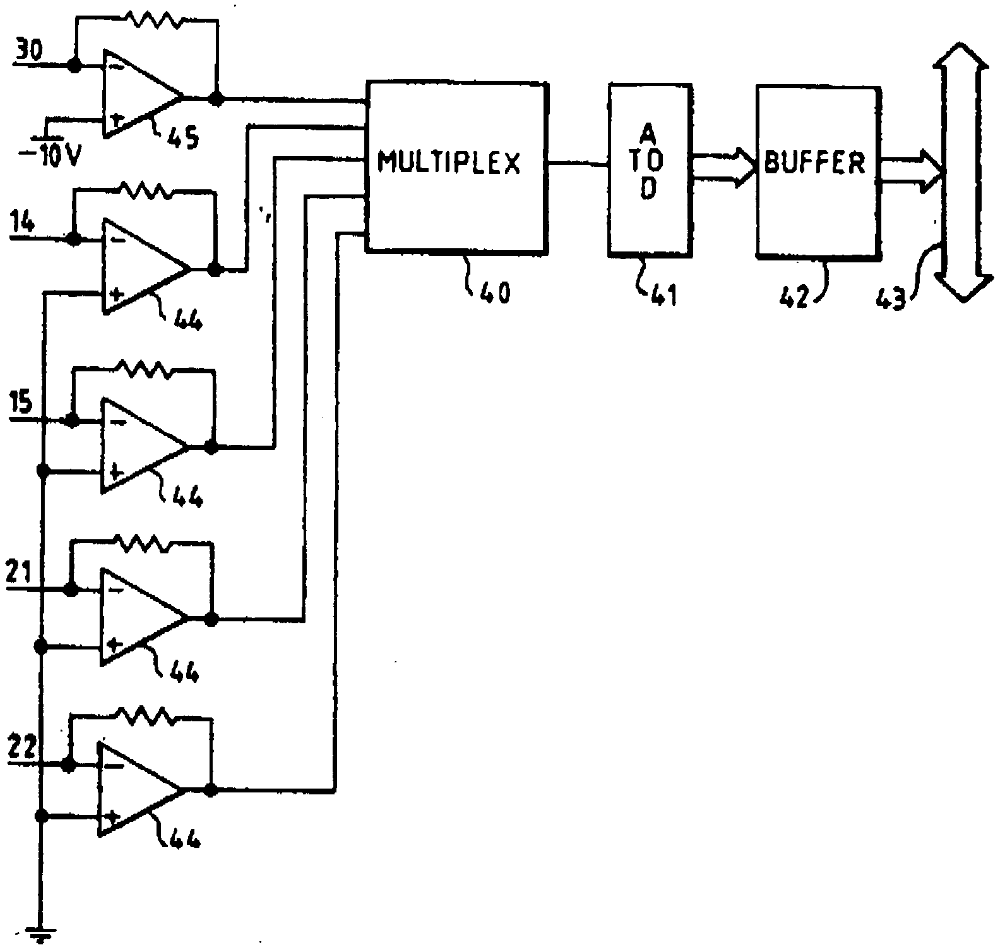
-10V
MULTIPLEX
A TO D
BUFFER

FIG 4

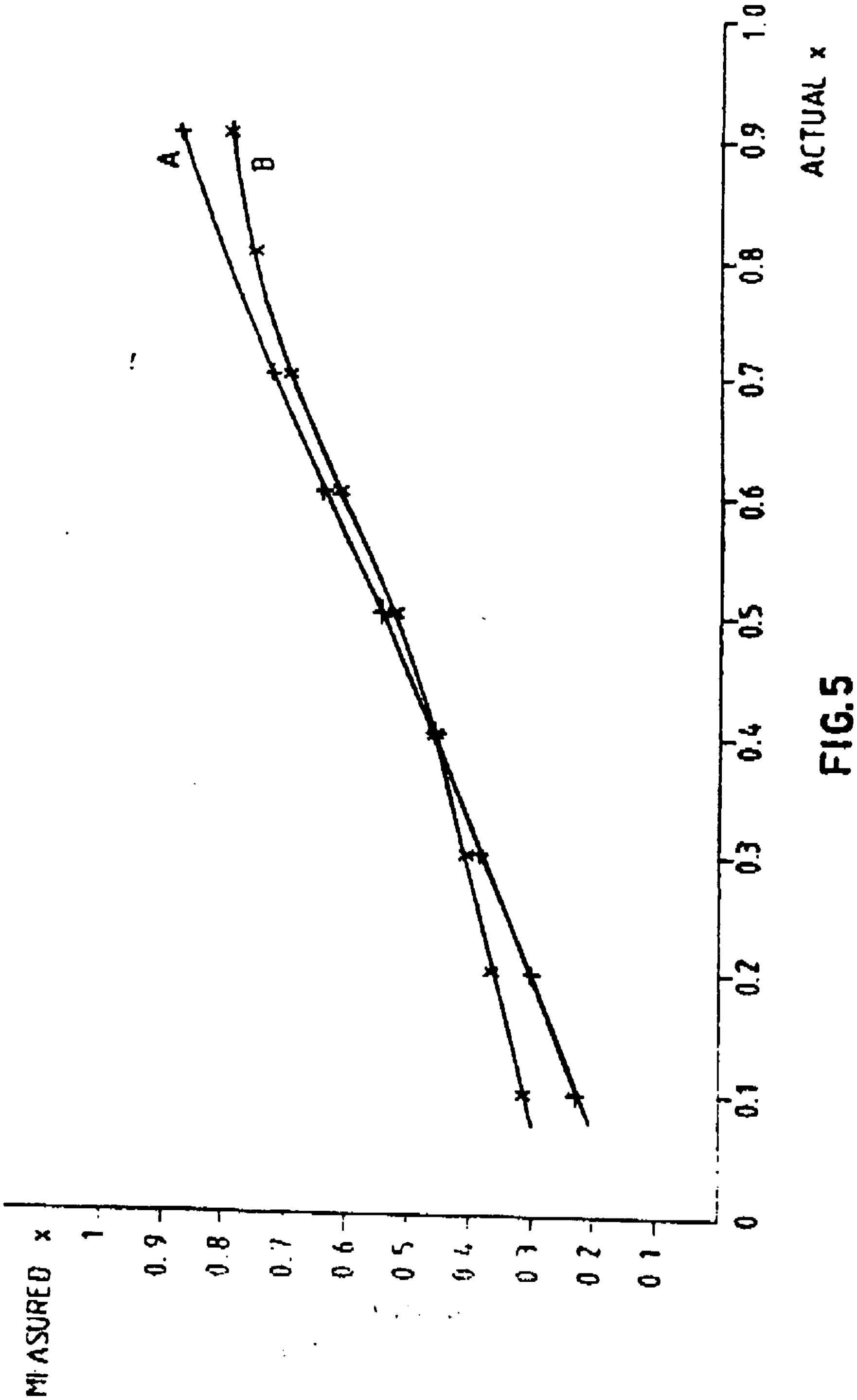
MEASURED x
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
ACTUAL x
A
B

FIG.5

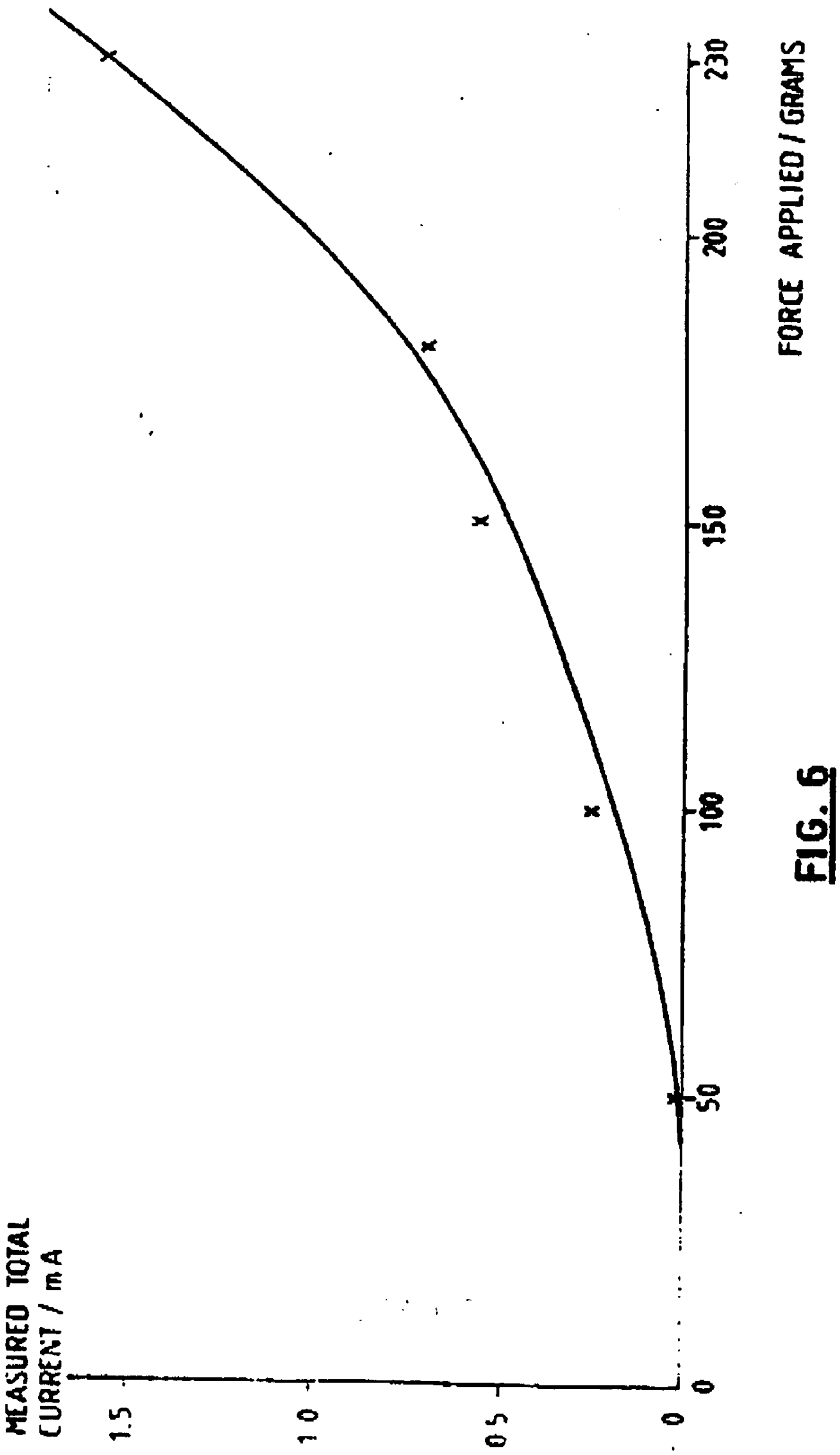
MEASURED TOTAL CURRENT / mA
1.5
1.0
0.5
0
0
50
100
150
200
230
FORCE APPLIED / GRAMS

FIG. 6